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**Original Research Article**

# Heterosis for Fruit Quality Components in Tomato (*Solanum lycopersicum* L.)

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**A B S T R A C T**

A study was conducted during crop season 2012-2013 at Vegetable Research Centre (VRC), G.B. Pantnagar, Uttarakhand. In this investigation 30 crosses were evolved in a line × tester mating design with 10 genotypes as female (10 lines, 3 testers and 30 $F_1$ hybrids) were evaluated for growth, yield and quality contributing traits. Highest significant relative heterosis and heterobeltiosis for fruit width and heterosis for pericarp thickness was observed in PT-20 × PT-3. Whereas, PT-09-06 × Punjab Chhuhara was most promising hybrid combination for the trait fruit shape index. Most promising hybrid for number of locules was PT-20 × Roma and PT-41 × Punjab Chhuhara showed highest significant heterosis and heterobeltiosis, respectively which exhibited negative heterosis. The promising combinations for pericarp thickness were PT-2009-02 × PT-3 and PT-2009-02 × Roma showing highest significant relative heterosis and heterobeltiosis, respectively.

**Keywords**

Heterosis, heterobeltiosis, quality traits and tomato

## Introduction

Tomato (*Solanum lycopersicum* L.) is native of Peru Ecuador Bolivia Region of Andes, South America (Rick, 1969). It is self-pollinated crop but a certain extent of cross pollination may take place. Tomato is a warm loving crop so easily tolerate heat and drought stress. In India, total tomato area and production was about 0.79 million hectare and 17.39 million tonnes, respectively during 2015 (Indian Horticulture Database, 2015). Tomato is mainly consumed as salad, cooked or processed into several products like ketchup, juice, puree, sauce and whole canned fruit. Tomato is a rich source of antioxidants (mainly lycopene and β- carotene), Vitamin A, Vitamin C and minerals like Ca, P, and Fe in diet (Saleem *et al.*, 2013). $F_1$ hybrid breeding is prominent among the methods used in the crop improvement of vegetable crops. Hybrids offer opportunities for improvement in productivity, earliness, uniformity and quality and for the rapid deployment of dominant genes for resistance to diseases and insect pests (Riggs, 1988). The present experiment was carried out to identify best combiner parents and best cross combination for developing promising hybrids for yield and its contributing traits using Line × Tester mating design.

## Materials and Methods

The present investigation was carried out during spring –summer season of 2012 and 2013 at Vegetable Research Centre (VRC)

of the G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Pantnagar is located at an altitude of 243.84 meters above mean sea level and at $29^0$ N latitude and $79.3^0$ E longitudes. Climate of Pantnagar is humid subtropical with maximum temperature ranging from $21^0$ C to $41^0$ C minimum ranging from $8.8^0$ C to $27.1^0$ C in summer. Soil type of the area is predominantly clay- loam. Genetically divers 10 lines (PT-41, S-06-1, PT-2009-02, PT-11, PT-19, S-816, PT-20, PT-0906, PT-1 and PT-11) were crossed with three testers (PT-3, Roma and Punjab Chhuhara) in line × tester mating. The most desirable tester is one which provides maximum information about the performance of a line in cross combinations under different environmental conditions. The criteria for selecting tester are broad genetic base, wider adaptability and poor in the trait for which line are to be evaluated.

The resultant 33 $F_1$ was evaluated along with their parents. The experiment was laid out in a Randomized Block design (RBD) with three replications with inter and intra row spacing 50 cm. Five competitive plants were randomly selected for recording the observations on different characters such as total soluble solid (°Brix), number of locules per fruit, pericarp thickness (mm), fruit length (cm), fruit width (cm), and fruit shape index. Data collected during the two growing season for above characters were pooled and analysis of variance and combining ability analysis were done as suggested by Panse and Sukhatme (1967) and kempthorne (1957), respectively.

## Results and Discussion

The mean performance of parents and hybrids and the estimate of relative heterosis and heterobeltiosis are presented in Tables 1 and 2. The heterosis over mid-parents ranged from 0.60 to 20.65 %, whereas heterosis ranged from -1.97 to 19.91 % for total soluble solid at turning stage. Highest positive heterobeltiosis for total soluble solid was observed in S-06-1 × Punjab Chhuhara (19.91 %). Most promising cross combination for higher TSS is S-06-1 × Punjab Chhuhara exhibited the highest heterosis over both mid-parent and better parent. Relative heterosis and heterobeltiosis for number of locules ranged from -33.65 to 49.36 % and -43.69 to 29.54 %, respectively.

The maximum positive heterosis over mid-parent and better parent for number of locules was observed in S-06-1 × PT-3 (29.54 %) respectively. The maximum negative heterosis over mid-parent and better parent observed in PT-20 × Roma (-33.65 %) and PT-41 × Punjab Chhuhara (-43.69 %), respectively. Juice increase with increase in number of locules, processing industries favour fruits with more number of locules observed in PT-41 × PT-3, in contrast less number of locules is favoured by farmer and consumer because these fruit will be firm. Most of the cross combinations showed negative heterosis indicating decrease in number of locules in hybrids and most significant decrease in locules numbers observed in PT-20 × Roma and PT-41 × Punjab Chhuhara.

Heterosis and heterobeltiosis for pericarp thickness ranged from -49.79 to 25.62 % and -51.53 to 22.16 % respectively. The maximum positive heterosis over mid-parent was observed in PT-2009-02 × PT-3 (25.62 %) and highest positive heterobeltiosis observed in PT-2009-02 × PT-3 (25.62 %) and highest positive heterobeltiosis observed in PT-2009-02 Roma (22.16 %). Fruit having more pericarp thickness withstand shipping and remain firm for more number of days as compared to thin fleshed fruit.

**Table.1** Mean performance of genotypes and F1 hybrids and extent of heterosis in tomato for fruit TSS, number of locules and pericarp thickness

| Genotypes | Total soluble solid (°Brix) | | | Number of locules per fruit | | | Pericarp thickness (mm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | MPH | BPH | Mean | MPH | BPH | Mean | MPH | BPH |
| Parents | | | | | | | | | |
| PT-41 | 4.62 | – | – | 3.75 | – | – | 3.00 | – | – |
| S-06-1 | 4.40 | – | – | 2.22 | – | – | 2.97 | – | – |
| PT-2009-02 | 4.54 | – | – | 3.45 | – | – | 3.70 | – | – |
| PT-11 | 4.59 | – | – | 4.20 | – | – | 3.34 | – | – |
| PT-19 | 4.58 | – | – | 3.19 | – | – | 4.05 | – | – |
| S-816 | 4.91 | – | – | 3.77 | – | – | 3.80 | – | – |
| PT-20 | 4.44 | – | – | 4.11 | – | – | 4.00 | – | – |
| PT-09-06 | 4.39 | – | – | 4.22 | – | – | 4.50 | – | – |
| PT-1 | 4.60 | – | – | 2.76 | – | – | 4.15 | – | – |
| PT-12 | 4.39 | – | – | 2.78 | – | – | 4.27 | – | – |
| PT-3 | 4.36 | – | – | 2.00 | – | – | 3.18 | – | – |
| Roma | 4.43 | – | – | 3.70 | – | – | 3.57 | – | – |
| Punjab Chhuhara | 4.41 | – | – | 2.33 | – | – | 4.46 | – | – |
| F1 Hybrids | | | | | | | | | |
| PT-41 x PT-3 | 4.68 | 4.27 | 1.37 | 4.30 | 49.36** | 14.48 | 3.27 | 5.66 | 2.62 |
| PT-41 x Roma | 4.61 | 1.84 | −0.22 | 3.53 | −5.37 | −6.04 | 3.76 | 14.52 | 5.42 |
| PT-41 x Punjab Chhuhara | 4.59 | 1.81 | −0.51 | 2.11 | −30.52** | −43.69** | 4.14 | 11.03 | −7.17 |
| S-06-1 x PT-3 | 5.18 | 18.39** | 17.89** | 2.88 | 36.39* | 29.54 | 2.99 | −2.71 | −5.97 |
| S-06-1 x Roma | 5.26 | 19.18** | 18.74** | 2.92 | −1.41 | −21.08* | 3.25 | −0.46 | −8.79 |
| S-06-1 x Punjab Chhuhara | 5.25 | 19.35** | 19.21** | 2.34 | 2.78 | 0.43 | 2.78 | −25.29** | −37.79** |
| PT-2009-02 x PT-3 | 5.14 | 15.39** | 13.06** | 3.33 | 22.08* | −3.57 | 4.32 | 25.62** | 16.85 |
| PT-2009-02 x Roma | 5.12 | 14.04** | 12.62* | 4.07 | 13.75 | 9.91 | 4.52 | 24.40** | 22.16* |
| PT-2009-02 x Punjab Chhuhara | 5.02 | 12.25** | 10.56* | 3.31 | 14.65 | −3.96 | 4.21 | 3.06 | −5.75 |
| PT-11 x PT-3 | 4.94 | 10.32* | 7.55 | 2.98 | −3.82 | −29.02** | 3.21 | −1.63 | −3.99 |
| PT-11 x Roma | 4.85 | 7.54 | 5.66 | 2.99 | −24.34** | −28.87** | 3.90 | 12.78 | 9.25 |
| PT-11 x Punjab Chhuhara | 4.88 | 8.41* | 6.25 | 3.01 | −7.86 | −28.39** | 3.34 | −14.35 | −25.09** |
| PT-19 x PT-3 | 4.72 | 5.48 | 2.91 | 3.75 | 44.29** | 17.33 | 3.83 | 5.90 | −5.43 |
| PT-19 x Roma | 4.73 | 4.88 | 3.13 | 2.88 | −16.34 | −22.07* | 4.11 | 7.83 | 1.40 |
| PT-19 x Punjab Chhuhara | 4.76 | 5.97 | 3.93 | 2.98 | 8.03 | −6.58 | 3.78 | −11.20 | −15.31 |
| S-816 x PT-3 | 5.12 | 10.46* | 4.28 | 2.63 | −8.84 | −30.24** | 3.95 | 13.07 | 3.86 |
| S-816 x Roma | 5.02 | 7.49 | 2.24 | 2.92 | −21.91** | −22.63* | 3.41 | −7.46 | −10.34 |
| S-816 x Punjab Chhuhara | 5.11 | 9.70* | 4.07 | 2.34 | −23.17* | −37.84** | 3.27 | −20.89** | −26.74** |
| PT-20 x PT-3 | 4.85 | 10.19* | 9.24 | 3.10 | 1.53 | −24.51** | 4.13 | 14.99 | 3.25 |
| PT-20 x Roma | 4.79 | 8.12 | 8.04 | 2.59 | −33.65** | −36.93** | 4.13 | 9.25 | 3.33 |
| PT-20 x Punjab Chhuhara | 4.83 | 9.23* | 8.87 | 2.98 | −7.30 | −27.35** | 4.54 | 7.37 | 1.79 |
| PT-09-06 x PT-3 | 4.86 | 11.01* | 10.63* | 3.18 | 2.25 | −24.64** | 3.87 | 0.82 | −13.93 |
| PT-09-06 x Roma | 4.70 | 6.50 | 6.02 | 3.13 | −20.96** | −25.83** | 4.02 | −0.25 | −10.59 |
| PT-09-06 x Punjab Chhuhara | 4.95 | 12.54** | 12.33* | 2.43 | −25.90** | −42.50** | 4.02 | −10.23 | −10.59 |
| PT-1 x PT-3 | 4.71 | 5.10 | 2.39 | 3.09 | 29.97* | 12.08 | 3.62 | −1.23 | −12.76 |
| PT-1 x Roma | 4.68 | 3.69 | 1.81 | 2.67 | −17.44 | −27.93** | 3.45 | −10.71 | −17.01* |
| PT-1 x Punjab Chhuhara | 4.68 | 4.04 | 1.89 | 2.97 | 16.83 | 7.73 | 2.16 | −49.79** | −51.53** |
| PT-12 x PT-3 | 5.13 | 17.21** | 16.77** | 3.11 | 30.13* | 11.87 | 3.52 | −5.64 | −17.64* |
| PT-12 x Roma | 5.08 | 15.15** | 14.67** | 3.13 | −3.50 | −15.50 | 4.23 | 8.04 | −0.86 |
| PT-12 x Punjab Chhuhara | 5.23 | 18.94** | 18.76** | 3.22 | 26.03* | 15.83 | 4.54 | 3.97 | 1.72 |

*Significant at 5%**significant at 1%

**Table.2** Mean performance of genotypes and F1 hybrids and extent of heterosis in tomato for fruit length, fruit width and fruit shape index

| Genotypes | Fruit length (cm) | | | Fruit width (cm) | | | Fruit shape index | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | MPH | BPH | Mean | MPH | BPH | Mean | MPH | BPH |
| **Parents** | | | | | | | | | |
| PT-41 | 3.48 | – | – | 4.04 | – | – | 0.96 | – | – |
| S-06-1 | 3.10 | – | – | 3.03 | – | – | 1.10 | – | – |
| PT-2009-02 | 3.54 | – | – | 4.08 | – | – | 0.79 | – | – |
| PT-11 | 3.76 | – | – | 4.33 | – | – | 0.88 | – | – |
| PT-19 | 3.80 | – | – | 3.88 | – | – | 1.12 | – | – |
| S-816 | 3.92 | – | – | 3.78 | – | – | 0.71 | – | – |
| PT-20 | 3.46 | – | – | 3.61 | – | – | 0.92 | – | – |
| PT-09-06 | 4.25 | – | – | 5.50 | – | – | 0.85 | – | – |
| PT-1 | 3.88 | – | – | 3.97 | – | – | 1.06 | – | – |
| PT-12 | 4.20 | – | – | 4.12 | – | – | 1.09 | – | – |
| PT-3 | 3.24 | – | – | 4.12 | – | – | 0.68 | – | – |
| Roma | 3.45 | – | – | 3.93 | – | – | 0.81 | – | – |
| Punjab Chhuhara | 4.58 | – | – | 4.18 | – | – | 0.86 | – | – |
| **Hybrids** | | | | | | | | | |
| PT-41 x PT-3 | 3.39 | 0.99 | −2.58 | 4.27 | 4.74 | 3.81 | 0.77 | −6.31** | −20.14** |
| PT-41 x Roma | 3.81 | 10.00 | 9.47 | 4.44 | 11.37 | 9.81 | 0.89 | 1.13 | −6.94** |
| PT x Punjab Chhuhara | 4.14 | 2.73 | −9.60 | 3.90 | −5.11 | −6.62 | 0.99 | 8.96** | 3.47* |
| S-06-1 x PT-3 | 3.12 | −1.47 | −3.60 | 3.30 | −7.60 | −19.76** | 0.89 | 0.00 | −19.15** |
| S-06-1 x Roma | 3.67 | 12.12 | 6.38 | 4.03 | 15.84* | 2.63 | 0.87 | −8.58** | −20.67** |
| S-06-1 x Punjab Chhuhara | 3.16 | −17.62** | −30.98** | 3.03 | −15.86* | −27.37** | 1.00 | 2.04 | −8.81** |
| PT-2009-02 x PT-3 | 3.97 | 17.32** | 12.35 | 4.38 | 6.83 | 6.40 | 0.82 | 11.36** | 3.38* |
| PT-2009-02 x Roma | 3.81 | 8.97 | 7.63 | 4.41 | 10.07 | 8.00 | 0.77 | −3.13* | −4.13* |
| PT-2009-02 x Punjab Chhuhara | 3.69 | −9.20 | −19.56** | 4.52 | 9.52 | 8.30 | 0.88 | 6.45** | 1.93 |
| PT-11 x PT-3 | 3.47 | −0.76 | −7.63 | 4.02 | −4.86 | −7.16 | 0.83 | 7.3** | −4.94** |
| PT-11 x Roma | 3.99 | 10.64 | 6.12 | 4.23 | 2.38 | −2.31 | 0.95 | 12.48** | 7.98** |
| PT-11 x Punjab Chhuhara | 3.90 | −6.47 | −14.91** | 4.43 | 4.12 | 2.31 | 0.86 | −1.53 | −2.28 |
| PT-19 x PT-3 | 3.73 | 5.92 | −1.93 | 4.18 | 4.59 | 1.54 | 0.93 | 3.72** | −16.72** |
| PT-19 x Roma | 3.45 | −4.74 | −9.12 | 3.94 | 1.02 | 0.34 | 0.94 | −1.91 | −15.52** |
| PT-19 x Punjab Chhuhara | 3.81 | −9.18 | −16.95** | 3.93 | −2.48 | −5.99 | 1.28 | 29.29** | 14.63** |
| S-816 x PT-3 | 3.34 | −6.80 | −14.95* | 3.16 | −19.92** | −23.16** | 0.99 | 42.93** | 39.25** |
| S-816 x Roma | 3.40 | −7.78 | −13.34* | 3.85 | −0.17 | −2.04 | 0.88 | 16.23** | 9.50** |
| S-816 x Punjab Chhuhara | 3.43 | −19.28** | −25.09** | 3.41 | −14.41* | −18.44* | 1.06 | 34.46** | 22.78** |
| PT-20 x PT-3 | 4.07 | 21.59** | 17.61* | 4.29 | 11.04 | 4.21 | 1.02 | 28.18** | 11.23** |
| PT-20 x Roma | 3.81 | 10.13 | 9.91 | 4.48 | 18.74** | 13.91 | 0.92 | 6.56** | 0.00 |
| PT-20 x Punjab Chhuhara | 5.09 | 26.51** | 11.05* | 4.76 | 22.35** | 14.05 | 1.07 | 20.37** | 16.67** |
| PT-09-06 x PT-3 | 4.17 | 11.26* | −2.04 | 4.61 | −4.16 | −16.19** | 0.84 | 10.24** | −1.17 |
| PT-09-06 x Roma | 3.96 | 2.73 | −6.97 | 4.43 | −5.94 | −19.35** | 0.85 | 2.41 | −0.39 |
| PT-09-06 x Punjab Chhuhara | 2.59 | −41.38** | −43.49** | 3.96 | −18.19** | −28.02** | 1.45 | 69.32** | 68.34** |
| PT-1 x PT-3 | 3.48 | −2.34 | −10.47 | 3.88 | −4.16 | −5.83 | 0.89 | 1.92 | −16.61** |
| PT-1 x Roma | 3.37 | −8.00 | −13.13* | 3.71 | −6.12 | −6.63 | 0.83 | −10.87** | −21.63** |
| PT-1 x Punjab Chhuhara | 2.60 | −38.50** | −43.20** | 4.71 | 15.50* | 12.69 | 1.15 | 19.38** | 8.15** |
| PT-12 x PT-3 | 3.82 | 2.78 | −8.98 | 4.23 | 2.63 | 2.59 | 0.89 | 0.57 | −18.40** |
| PT-12 x Roma | 4.59 | 20.05** | 9.37 | 4.55 | 13.04* | 10.44 | 0.91 | −3.87** | −16.26** |
| PT-12 x Punjab Chhuhara | 4.32 | −1.59 | −5.75 | 4.25 | 2.45 | 1.76 | 1.10 | 13.16** | 1.53 |

*Significant at 5%**significant at 1%

Most promising hybrid in terms of higher pericarp thickness was PT-2009-02 × PT-3 (25.62 %) for heterosis and PT-2009-02 × Roma (22.16 %) for heterobeltiosis. Similar observations were also reported by Kurian *et al.,* (2001), Singh *et al.,* (2006), Kumar *et al.,* (2006) and Asati *et al.,* (2007). The maximum positive heterosis over mid-parent observed in PT-20 × Punjab Chhuhara (26.51 %), while PT-20 × PT-3 (17.61 %) showed maximum positive heterobeltiosis. Cross combinations, PT-20 × PT-3 (17.61 %), PT-20 × Punjab Chhuhara (11.05 %) were observed positive significant heterobeltiosis over better parent for fruit length. The relative heterosis and heterobeltiosis for fruit width ranged from -19.92 % to 22.35 % and -28.02 to 14.05 % respectively. The maximum positive heterosis over mid-parent for fruit width observed in PT-20 × Punjab Chhuhara (22.35 %) and highest significant relative heterosis and heterobeltiosis for fruit width and heterosis for pericarp thickness was observed in PT-20 × Punjab Chhuhara.

For fruit shape index the ranged from -10.87 to 69.32 % and -21.63 to 68.34 % for heterosis and heterobeltiosis, respectively. The maximum positive and negative heterosis over mid-parent for fruit shape index were observed in PT-09-06 × Punjab Chhuhara (69.32 %) and PT-1 × Roma (-10.87 %), respectively. The highest positive and negative value for heterobeltiosis for fruit shape index was observed in PT-09-06 × Punjab Chhuhara (68.34 %) and PT-1 × Roma (-21.63 %), respectively.

In conclusion, the present investigation suggests that study resulted into identification of hybrid for tomato fruit quality. Hybrid PT-20 × Punjab Chhuhara showed highest significant heterosis for pericarp thickness. Most promising hybrid combination PT-09-06 × Punjab Chhuhara for fruit shape index and S-06-1 × Punjab Chhuhara for total soluble solid at turning stage.

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